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(54) [Title of the Invention] VARIABLE WAVELENGTH LIGHT SOURCE
APPARATUS

30 (57) [Abstract]

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[Object] To control the constant intensity of laser light in a wide wavelength range.

[Solving Means] A polarizing plate 2a transmitting only laser light of one polarization component of a polarization angle by which a branching ratio of a
5 branching plate 3 can be obtained, is provided on a light path between a variable wavelength light source 1 outputting laser light and the branching plate 3 branching incident light into output light and reference light at a predetermined branching ratio in accordance with a polarization angle of the incident light. An optical receiver 4
10 receives reference light from the branching plate 3 and outputs a detection signal in accordance with the intensity of branched light. A control circuit 5 controls the intensity of laser light output from the variable wavelength light source 1 in accordance with change of the detection signal from the optical receiver 4.

[Scope of Claim]

15 [Claim 1] A variable wavelength light source apparatus characterized by comprising:

a variable wavelength light source (1) for outputting light, which is controlled to be a predetermined wavelength;

20 a branching means (3) for branching incident light at a predetermined branching ratio in accordance with a polarization angle of the incident light and outputting one as output light and the other as reference light;

a polarizing means (2), which is provided on a light path between the variable wavelength light source and the branching means, for receiving light from the variable wavelength light source and transmitting only one polarization component of a
25 polarization angle by which the branching ratio can be obtained among the received light through the branching means;

an intensity detecting means (4) for receiving the reference light branched by the branching means and outputting a detection signal in accordance with intensity of the received reference light; and

30 a controlling means (5) for receiving the detection signal output from the

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intensity detecting means, and making the intensity of the reference light or the output light a desired value by controlling the intensity of light output from the variable wavelength light source in accordance with change in the detection signal.

5 [Claim 2] A variable wavelength light source apparatus characterized by comprising:

a variable wavelength light source (1) for outputting light, which is controlled to be a predetermined wavelength;

an intensity varying means (11) for receiving light from the variable
10 wavelength light source, varying intensity of the received light, and outputting the light;

a branching means (3) for branching incident light at a predetermined branching ratio in accordance with a polarization angle of the incident light and outputting one as output light and the other as reference light;

a polarizing means (2), which is provided on a light path between the intensity
15 varying means and the branching means, for receiving light from the intensity varying means and transmitting only one polarization component of a polarization angle by which the branching ratio can be obtained among the received light through the branching means;

an intensity detecting means (4) for receiving the reference light branched by
20 the branching means and outputting a detection signal in accordance with intensity of the received reference light; and

a controlling means (5) for receiving the detection signal output from the intensity detecting means, and making the intensity of the reference light or the output light a desired value by controlling the intensity of light output from the intensity
25 varying means in accordance with change in the detection signal.

[Claim 3] The variable wavelength light source apparatus according to claim 1 or claim 2, wherein the polarizing means (2) includes a light polarizer or an optical isolator having a light polarizer and a Faraday element.

[Claim 4] The variable wavelength light source apparatus according to claim 1
30 or claim 2, further comprising a wavelength/intensity setting means (6) for setting the

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predetermined wavelength with respect to the variable wavelength light source (1) and setting the desired value with respect to the controlling means (5).

[Detailed Description of the Invention]

[0001]

5 [Field of the Invention] The present invention relates to a variable wavelength light source apparatus which can vary a wavelength of laser light, and in particular, relates to a variable wavelength light source apparatus for outputting the laser light with more stable output intensity in a wide wavelength range at a certain level.

[0002]

10 [Conventional Art] A variable wavelength light source, which is generally used as a light source of a variable wavelength light source apparatus, is configured in such a way that the variable wavelength light source outputs one of many modes that a semiconductor laser element can oscillate by selecting it with a wavelength selecting portion. Further, as this kind of variable wavelength light source, there are an external
15 resonance type in which a semiconductor laser element and a wavelength selecting portion are independently provided and one in which a semiconductor laser element and a wavelength selecting portion are combined.

[0003] FIG 9 shows a structure of a variable wavelength light source of an external resonance type. This variable wavelength light source includes a semiconductor laser
20 element 21 generating laser light by being supplied with power, and a wavelength selecting portion 22 returning only a predetermined wavelength of laser light output from a non-reflective coating in one side of the semiconductor laser element 21 to the semiconductor laser element 21. In a case where this wavelength selecting portion 22 is composed of a diffraction grating, by rotating the diffraction grating, a wavelength of
25 oscillated laser light can be varied.

[0004] The intensity of output light with respect to a wavelength of this kind of variable wavelength light source is changed with change in the wavelength, and the intensity is also changed with change in ambient temperature, etc.

[0005] To solve the above described problem, the present applicant had already filed a
30 patent application on a variable wavelength light source apparatus being capable of

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varying a wavelength of laser light, which is disclosed in Japanese Patent Application Laid-Open No. Hei 8-172233.

[0006] An structural example of the variable wavelength light source apparatus will be described with reference to FIG. 10 as follows. The variable wavelength light source apparatus performs the setting of a wavelength λ with respect to a variable wavelength light source 31 and the outputting of a set value S with respect to a control circuit 32 by a wavelength/intensity setting device 33. The intensity of laser light output from the variable wavelength light source 31 is varied by an intensity varying means 34 such as an optical attenuator and an optical amplifier. Part of this varied laser light is branched by a branching means 35, and the branched light is received by an optical receiver 36. The control circuit 32 controls the constant intensity of laser light based on change in a light receiving signal of the optical receiver 36. When controlling the intensity of laser light, a received signal level, by which the intensity of laser light is made constant, for each wavelength is stored in a wavelength intensity characteristic storage device 37 in advance, and then the intensity of laser light is controlled such that it becomes the received signal level of the wavelength at the time of outputting the laser light.

[0007]

[Means for Solving the Problems] Meanwhile, in the branching means 35 of the variable wavelength light source apparatus, a branching ratio is set in advance in accordance with a polarized wave state of light of a wavelength to be used. Therefore, when the polarized wave state is changed during a period of inputting light to the branching means 35, a branching ratio of output light to branched light, which are branched by the branching means 35, is varied.

[0008] However, in the above variable wavelength light source apparatus, when the intensity varying means 34 is connected between the variable wavelength light source 31 and the branching means 35 through an optical fiber, a polarized wave state is altered at a connection portion of the optical fiber, or when the attenuation amount or the amplification degree of the intensity varying means 34 is varied, a polarization extinction ratio of laser light is changed or fluctuation of a polarized wave is generated. As a consequence, laser light output from the variable wavelength light source 31 is

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changed in its polarization state during a period of being input to the branching means 35. Accordingly, light is output at a state, which is different from an original branching ratio, from the branching means 35. Further, since the control circuit 32 controls the intensity varying means 34 in accordance with change in level of branched
5 light received by the optical receiver 36 to vary the intensity of laser light, it has been impossible to control the intensity of laser light to be constant.

[0009] As mentioned above, in the above described conventional variable wavelength light source apparatus, when a polarization extinction ratio of laser light is changed or fluctuation in a polarized wave is generated during a period of inputting laser light
10 output from the variable wavelength light source 31 to the branching means 35, it has been impossible to output laser light at a constant level in an entire area of a wide wavelength range.

[0010] Therefore, the present invention is made in view of the above problems. It is an object of the present invention to provide a variable wavelength light source
15 apparatus which can output laser light at a constant level in a wide wavelength range without changing a polarization extinction ratio of the laser light and without changing a branching ratio due to fluctuation in a polarized wave.

[0011]

[Means for Solving the Problems] To achieve the above object, the present invention
20 according to claim 1 is characterized by including a variable wavelength light source 1 for outputting light, which is controlled to have a predetermined wavelength; a branching means 3 for branching incident light at a predetermined branching ratio in accordance with its polarization angle and outputting one as output light and the other as reference light; a polarizing means 2, which is provided on a light path between the
25 variable wavelength light source and the branching means, for receiving light from the variable wavelength light source and transmitting only one polarization component of a polarization angle by which the branching ratio is obtained among the received light through the branching means; an intensity detecting means 4 for receiving the reference light branched by the branching means and outputting a detection signal in accordance
30 with the intensity of the received reference light; and a controlling means 5 for making

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the intensity of the reference light or the output light a desirable value by receiving the detection signal output from the intensity detecting means and controlling the intensity of light output from the variable wavelength light source.

[0012] The present invention according to claim 2 is characterized by including a
5 variable wavelength light source 1 for outputting light, which is controlled to have a predetermined wavelength; an intensity varying means 11 for receiving light from the variable wavelength light source and varying the intensity of the received light to output; a branching means 3 for branching incident light at a predetermined branching ratio in accordance with its polarization angle and outputting one as output light and the
10 other as reference light; a polarizing means 2, which is provided on a light path between the intensity varying means and the branching means, for receiving light from the intensity varying means and transmitting only one polarization component of a polarization angle by which the branching ratio is obtained among the receiving light through the branching means; an intensity detecting means 4 for receiving the reference
15 light branched by the branching means and outputting a detection signal in accordance with the intensity of the received reference light; and a controlling means 5 for making the intensity of the reference light or the output light a desirable value by receiving the detection signal output from the intensity detecting means and controlling the intensity of light output from the intensity varying means in accordance with change in the
20 detection signal.

[0013] In the variable wavelength light source apparatus according to claim 1 or claim 2, the present invention of claim 3 is characterized in that the polarizing means 2 includes a light polarizer 2a or an optical isolator 2b with the light polarizer and a Faraday element.

25 [0014] In the variable wavelength light source apparatus according to claim 1 or claim 2, the present invention of claim 4 is characterized by including a wavelength/intensity setting means 6 for setting the predetermined wavelength with respect to the variable wavelength light source 1 and setting the desired value with respect to the controlling means 5.

30 [0015] According to the variable wavelength light source apparatus of the present

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invention, even when a polarized wave state of light output from the variable wavelength light source 1 is changed, light including only one polarization component of a polarization angle by which a spectral ratio of the branching means 3 can be obtained, enters in the branching means 3 by the polarizing means 2 provided in a previous stage of the branching means 3. Therefore, the constant light intensity can be controlled in a wide wavelength range without changing a polarization extinction ratio of light or changing a branching ratio of the branching means 3 due to fluctuation in a polarized wave.

[0016]

[Embodiment Modes of the Invention] Embodiment modes of the present invention will be hereinafter described with reference to the drawings. FIG. 1 is a diagram showing the first embodiment mode of a variable wavelength light source apparatus according to the present invention. FIG. 2 is a diagram showing one structural example of a variable wavelength light source used in the apparatus.

[0017] As shown in FIG. 1, the variable wavelength light source apparatus of the first embodiment mode schematically includes a variable wavelength light source 1, a polarizing means 2, a branching plate 3, an optical receiver 4, a control circuit 5, a wavelength/intensity setting device 6, and a wavelength intensity characteristic storage device 7.

[0018] As shown in FIG. 2, the variable wavelength light source 1 is of an external resonance type and includes a semiconductor laser element 8 driven at constant active layer current, a wavelength selecting portion 9 provided at one end of the semiconductor laser element 8, and a lens 10 making laser light output from the other end of the semiconductor laser element 8 parallel light and outputting the parallel light to an external portion. The variable wavelength light source 1 is configured such that an optical condition of the wavelength selecting portion 9 is varied by external control and a wavelength of laser light oscillated and output from the semiconductor laser element 8 is changed.

[0019] The wavelength selecting portion 9 includes a lens 9a, which makes laser light output from a non-reflective coating at one end of the semiconductor laser element 8

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parallel light, and a diffraction grating 9b, which returns only a desired wavelength to the semiconductor laser element 8 side upon receiving the parallel light. In this wavelength selecting portion 9, a wavelength is selected by turning the diffraction grating 9b by a turning apparatus not shown in the drawings. An angle of this
5 diffraction grating 9b is set in accordance with wavelength information λ from the wavelength/intensity setting device 6.

[0020] Laser light output from the variable wavelength light source 1 is input to the polarizing means 2. The light polarizer 2a as the polarizing means 2 is placed on a light path (an optical axis) between the variable wavelength light source 1 and the
10 branching plate 3, and transmits only light including one polarization component of input laser light through the branching plate 3 side. A polarization angle of the light polarizer 2a is set such that transmitted light becomes in a polarized wave state by which a branching ratio set in the spectral plate 3 can be obtained.

[0021] The branching plate 3 as a branching means is, for example, formed using a
15 material having extremely slight change in light transmittance T (reflectance $1-T$) like a plate in which a dielectric multilayer film is evaporated on glass, or the like. The branching plate 3 branches laser light with intensity P_1 output from the light polarizer 2a into output light with intensity $T \cdot P_1$ and reference light with intensity $(1-T) \cdot P_1$. A branching ratio of the intensity in the branching plate 3 is previously set to be a desired
20 value in accordance with a polarized wave state of incident light.

[0022] The reference light branched by the branching plate 3 is received by the optical receiver 4 as an intensity detecting means. The optical receiver 4 outputs a detection signal P_s with the size in proportion to the intensity $(1-T) \cdot P_1$ of the reference light to be input, i.e., with the size in proportion to the intensity $P_o (=T \cdot P_1)$ of the output light.

[0023] The wavelength/intensity setting device 6 as a setting means sends wavelength
25 information λ , which is set, to the variable wavelength light source 1 from an operating portion, an external apparatus or the like not shown in the drawings. Then, the variable wavelength light source 1 outputs laser light with a wavelength corresponding to the wavelength information of the wavelength/intensity setting device 6 by a control
30 signal from the control circuit 5. Further, in the wavelength/intensity setting device 6,

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a set value S for setting the intensity P_o of the output light of the variable wavelength light source apparatus is set from an operating portion, an external apparatus or the like not shown in the drawings. A characteristic of intensity with respect to a wavelength of the variable wavelength light source 1 is previously stored in the wavelength intensity characteristic storage device 7 as a storing means.

[0024] The set value S set by the wavelength/intensity setting device 6 is input to the control circuit 5 along with the detection signal P_s detected by the optical receiver 4. The control circuit 5 as a controlling means includes, for example, a differential amplifier with enormous gain and the like. The control circuit 5 detects difference between the set value S and the detection signal P_s , supplies amplification output for a component of the difference as a control signal to the variable wavelength light source 1, and controls the intensity P_o of the output light of the variable wavelength light source 1 so as to be equal to the set value S.

[0025] Note that the wavelength/intensity setting device 6 may be configured in such a way that after performing determination and correction of the wavelength information λ input from the operating portion or the like not shown in the drawings or the set value S of the intensity of the output light by a microcomputer, the wavelength/intensity setting device 6 outputs the wavelength information λ or the set value S to the variable wavelength light source 1 or the control circuit 5 through a D/A converter.

[0026] Further, the wavelength/intensity setting device 6 may be configured in such a way that when the set value S and the wavelength λ are set by the operating portion not shown in the drawings, the wavelength/intensity setting device reads out intensity information corresponding to the set wavelength λ from the wavelength intensity characteristic storage device 7; calculates an upper limit of the set value within a range capable of controlling laser light with this wavelength at a constant intensity; and compares the calculated value and the set value S set from an external portion, whereas when the set value S is larger than the upper limit, the wavelength/intensity setting device displays alarm on a display device or the like or provides alert warning with sound.

[0027] Furthermore, the wavelength/intensity setting device 6 may read out a

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wavelength range where it can output with intensity equal to the set value S, from the wavelength intensity characteristic storage device 7; determine whether or not a wavelength set from an external portion is within this wavelength range; and display alarm on the display device or the like or provide alert warning with sound when the set
5 wavelength information is out of the wavelength range.

[0028] As set forth above, in the variable wavelength light source apparatus of the first embodiment mode, the light polarizer 2a through which only one polarization component passes is placed on a light path between the variable wavelength light source 1 and the branching plate 3. Then, light passing through the light polarizer 2a is
10 branched into output light and reference light by the branching plate 3. The reference light branched by the branching plate 3 is received by the optical receiver 4, and a detection signal in accordance with the intensity of the reference light is output from the optical receiver. The detection signal output from the optical receiver 4 is input to the control circuit 5. The control circuit 5 varies a control signal with respect to the
15 variable wavelength light source 1 in accordance with change in the detection signal, and controls such that the intensity of laser light output from the variable wavelength light source 1 is made constant.

[0029] Accordingly, light input to the branching plate 3 becomes a constant polarized wave, which always obtains a spectral ratio of the spectral plate 3 by the light polarizer
20 2a so that the constant intensity of laser light can be controlled in a wide wavelength range without changing a polarization extinction ratio of laser light or without changing a branching ratio of the branching plate 3 due to fluctuation in a polarized wave. Further, even when the intensity of output light of the variable wavelength light source 1 is changed due to variable operation of a wavelength, environmental change or the like,
25 the intensity of laser light output from the variable wavelength light source apparatus is kept constant by the above described control.

[0030] Further, the above described intensity control is performed with respect to laser light output from the variable wavelength light source 1 without changing active layer current of the semiconductor laser element 8 inside the variable wavelength light source
30 1, and therefore, there is no mode hop or no fluctuation in wavelength due to the

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intensity control and laser light with stable intensity and a stable wavelength can be output. Accordingly, even in a case where responses to wavelengths of various kinds of optical components or optical devices are measured, highly accurate measurement can be carried out by using laser light output from this variable wavelength light source apparatus.

[0031] Next, FIG 3 is a diagram showing the second embodiment mode of a variable wavelength light source apparatus according to the present invention. Note that in the second embodiment mode, structural components identical to those of the first embodiment mode are denoted by the same reference numerals, and explanation thereof is omitted.

[0032] In the variable wavelength light source apparatus of the second embodiment mode, an optical attenuator 11a is provided as an intensity varying means 11 on a light path (an optical axis) between the variable wavelength light source 1 and the light polarizer 2a, and other structure is the same as the first embodiment mode.

[0033] The optical attenuator 11a includes, for example, a Faraday element for rotating a polarization plane to incident light by an angle corresponding to the intensity of magnetic field to be applied, a coil for applying magnetic field to the Faraday element, and a light polarizer with a fixed polarized wave plane, for outputting only a component corresponding to the polarization plane of components of light passing through the Faraday element.

[0034] A further explanation will be provided below. In a case where a polarization plane of the light polarizer is deviated for a predetermined angle from a polarization plane of laser light output from the variable wavelength light source and the Faraday element is in a state of applying no magnetic field (a state of feeding no current to the coil), incident light is output to the light polarizer without changing the polarization plane of the incident light. Therefore, when magnetic field applied to the Faraday element is controlled by a control signal from the control circuit 5, the attenuation amount of laser light from the variable wavelength light source 1 can be varied so that the intensity of output light can be made constant.

[0035] Next, FIG. 4 is a diagram showing the third embodiment mode of a variable

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wavelength light source apparatus according to the present invention. Note that in the third embodiment mode, structural components identical to those of the first embodiment mode are denoted by the same reference numerals, and explanation thereof is omitted.

5 [0036] In the variable wavelength light source apparatus of the third embodiment mode, an optical amplifier 11b is provided as an intensity varying means 11 on a light path between the variable wavelength light source 1 and the light polarizer 2, and other structure is the same as the first embodiment mode.

[0037] The optical amplifier 11b includes, for example, a semiconductor laser
10 amplifier using a semiconductor laser element as an amplifying element and amplifying and outputting input light by current injected to the semiconductor laser element, a fiber amplifier, or the like. Then, when the amplification degree of the optical amplifier 11b is controlled by a control signal from the control circuit 5, the intensity of output light can be made constant.

15 [0038] Note that when using the semiconductor laser amplifier as the optical amplifier 11b, current injected to the semiconductor laser element is varied to vary and control the amplification degree. Since this semiconductor laser amplifier has high-speed response and can attenuate input light in a range of a small amount of injected current, the intensity of output light can be varied in a wide range.

20 [0039] Further, in a case of using the fiber amplifier as the optical amplifier 11b, the amplification degree is controlled by varying current injected to a semiconductor laser element for excitation.

[0040] Note that in many cases in such an optical amplifier 11b, an amplifiable
25 wavelength band is limited and the amplification degree is changed depending on a wavelength; however, laser light with constant intensity can be always output by control of the control circuit 5 without being adversely affected by change in amplification degree due to a wavelength of the optical amplifier 11b so long as an amplifiable wavelength band of the optical amplifier 11b corresponds to a wavelength variable band of the variable wavelength light source 1.

30 [0041] Then, laser light passing through the intensity varying means 11 according to

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the second embodiment mode and the third embodiment mode is input to the light polarizer 2 as a polarizing means. The light polarizer 2 transmits only light with one polarization component of input laser light through the branching plate 3 side.

[0042] As described above, in each of the variable wavelength light source apparatuses of the second embodiment mode and the third embodiment mode, the light polarizer 2 through which only one polarization component passes is placed on a light path between the intensity varying means (the optical attenuator 11a or the optical amplifier 11b) 11 and the branching plate 3. Then, light passing through the light polarizer 2 is branched into output light and reference light by the branching plate 3.

10 The reference light branched by the branching plate 3 is received by the optical receiver 4 and a detection signal in accordance with the intensity of the reference light is output from the optical receiver. The detection signal output from the optical receiver 4 is input to the control circuit 5. The control circuit 5 varies a control signal with respect to the intensity varying means 11 in accordance with change in the detection signal and

15 controls the intensity of laser light output from the intensity varying means 11 to be constant.

[0043] Accordingly, light input to the branching plate 3 becomes a constant polarized wave by which a spectral ratio of the spectral plate 3 can be always obtained, by the light polarizer 2 as well as the first embodiment mode, and therefore, constant intensity

20 of laser light can be controlled in a wide wavelength range without changing a polarization extinction ratio of laser light or a branching ratio of the branching plate 3 due to fluctuation in a polarized wave.

[0044] Further, after laser light, which passes through the intensity varying means 11, is transmitted through the light polarizer 2, the laser light is branched into output light

25 and reference light by the branching plate 3, and the attenuation amount and the amplification degree of the intensity varying means 11 are controlled based on the intensity of the reference light. Therefore, there are no adverse effects due to variation in characteristic of the intensity varying means 11 (variation in attenuation amount depending on change in a wavelength of input light or environmental change) or

30 nonlinearity of the attenuation amount.

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[0045] Next, FIG. 5 is a diagram showing the fourth embodiment mode of a variable wavelength light source apparatus according to the present invention. Note that in the fourth embodiment mode, structural components identical to those of the first embodiment mode are denoted by the same reference numerals, and explanation thereof is omitted.

[0046] In the variable wavelength light source apparatus of the fourth embodiment mode, an optical isolator 2b is provided as a polarizing means 2 on a light path (an optical axis) between the variable wavelength light source 1 and the branching plate 3, and other structure is the same as that of the first embodiment mode.

10 [0047] The optical isolator 2b as the polarizing means includes a Faraday element and a light polarizer. In this optical isolator 2b, when the direction and the strength of magnetic field applied to the Faraday element are varied and controlled, a polarization plane of incident light in the Faraday element is rotated by an angle in accordance with the strength of the magnetic field to be applied. After laser light from the variable
15 wavelength light source 1 is polarized by the Faraday element and then transmitted therethrough, only one polarization component of components of the laser light passes through the light polarizer and then enters in the branching plate 3. Note that a polarization angle of the light polarizer included in the optical isolator 2b is set such that the transmitted light becomes in a polarized wave state by which a branching ratio set in
20 the spectral plate 3 can be obtained.

[0048] Accordingly, since the variable wavelength light source apparatus of the fourth embodiment mode has a structure in which the optical isolator 2b is used as the polarizing means 2, output light of the optical isolator 2b becomes a constant polarized wave by which a spectral ratio of the spectral plate 3 can be obtained as well as the case
25 of using the light polarizer 2a, and hence, the same effect as the above described first and second embodiment modes can be obtained. In addition, an adverse effect due to light returning to the variable wavelength light source 1 is removed so that laser light output with more stable intensity can be obtained.

[0049] Next, FIG. 6 is a diagram showing the fifth embodiment mode of a variable
30 wavelength light source apparatus according to the present invention. Note that in

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the fifth embodiment mode, structural components identical to those of the second embodiment mode are denoted by the same reference numerals, and explanation thereof is omitted.

5 [0050] In the variable wavelength light source apparatus of the fifth embodiment mode, an optical isolator 2b is provided as a polarizing means 2 on a light path between the intensity varying means 11 and the branching plate 3, and other structure is the same as the second embodiment mode.

[0051] The variable wavelength light source apparatus of the fifth embodiment mode has a structure in which the optical isolator 2b is used as the polarizing means 2 as well as the fourth embodiment mode. Therefore, as well as the case of using the light polarizer 2a, output light of the optical isolator 2b becomes a constant polarized wave by which a spectral ratio of a spectral plate 3 can be obtained, and the same effect as the above described first and second embodiment modes can be obtained. In addition, an adverse effect due to light returning to the variable wavelength light source 1 is removed so that output of laser light with more stable intensity can be obtained.

15 [0052] Next, FIG. 7 is a diagram showing the sixth embodiment mode of a variable wavelength light source apparatus according to the present invention. Note that in the sixth embodiment mode, structural components identical to those of the fifth embodiment mode are denoted by the same reference numerals, and explanation thereof is omitted.

[0053] In the variable wavelength light source apparatus of the sixth embodiment mode, an intensity varying means 11 includes an optical amplifier 11c and an optical attenuator 11d, and other structure is the same as the fifth embodiment mode.

25 [0054] The optical amplifier 11c is provided on a light path (an optical axis) between the variable wavelength light source 1 and the optical isolator 2b. In the optical amplifier 11c, the amplification degree is continuously varied and controlled by a control signal output from the control circuit 5 in accordance with change in a detection signal output from the optical receiver 4. The optical amplifier amplifies laser light from the variable wavelength light source 1 by the amplification degree, which is varied and controlled, and then outputs the amplified laser light to the optical attenuator 11d.

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[0055] The optical attenuator 11d roughly varies and controls the attenuation amount by the control circuit 5, attenuates light from the optical amplifier 11c by the attenuation amount, which is varied and controlled, and then outputs to the optical isolator 2b.

5 [0056] Next, FIG. 8 is a diagram showing the seventh embodiment mode of a variable wavelength light source apparatus according to the present invention. Note that in the seventh embodiment mode, structural components identical to those of the sixth embodiment mode are denoted by the same reference numerals, and explanation thereof is omitted.

10 [0057] The variable wavelength light source apparatus of the seventh embodiment mode uses an optical attenuator 11e as substitute for the optical amplifier 11c of the sixth embodiment mode.

15 [0058] The optical attenuator 11e is provided on a light path (an optical axis) between the variable wavelength light source 1 and the optical isolator 2b. The optical attenuator 11e continuously varies and controls the attenuation amount by a control signal output from the control circuit 5 in accordance with change in a detection signal output from the optical receiver 4, attenuates laser light from the variable wavelength light source 1 by the attenuation amount, which is varied and controlled, and then outputs to the optical attenuator 11d.

20 [0059] The optical attenuator 11d includes, for example, an ND (Natural Density) filter which can set different attenuation amounts. The optical attenuator 11d roughly varies and controls the attenuation amount, attenuates light from the optical amplifier 11e by the attenuation amount, which is varied and controlled, and then outputs the attenuated light to the optical isolator 2b.

25 [0060] Note that in the structure of FIG. 7 or FIG. 8, a light polarizer 2a may be provided as substitute for the optical isolator 2b.

30 [0061] As set forth above, the same effect as the fourth embodiment mode can be obtained by the variable wavelength light source apparatuses showing the sixth and seventh embodiment modes. That is, output light of the optical isolator 2b becomes a constant polarized wave by which a spectral ratio of the spectral plate 3 can be obtained, and therefore, constant intensity of laser light can be controlled in a wide wavelength

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range without changing a polarization extinction ratio of laser light and without changing the branching ratio of the branching plate 3 due to fluctuation in a polarized wave. Furthermore, an adverse effect due to light returning to the variable wavelength light source 1 is removed so that output of laser light with more stable intensity can be
5 obtained.

[0062] Meanwhile, as the intensity varying means 11, in addition to an optical attenuator by rotation of a polarization plane, an optical attenuating type using an electro-optical effect or an acoustooptical effect by lithium niobate (LiNbO_3) as disclosed in Japanese Patent Application Laid-Open No. Hei 8-172233, an optical
10 amplifying type using a semiconductor laser amplifier or a fiber amplifier, and the like can be used.

[0063] Moreover, examples of using the variable wavelength light source 1 of the external resonance type are described in the above embodiment modes; however, as an integral variable wavelength light source element, a variable wavelength light source
15 element of a black-reflective type as disclosed in Japanese Patent Application Laid-Open No. Hei 8-172233, a variable wavelength light source element of a distributed-feedback (DFB) type, and the like can also be used.

[0064]

[Effect of the Invention] As described above, according to the present invention, light
20 input to a branching means is made to be a constant polarized wave by a polarizing means, and hence, constant intensity of laser light can be controlled in a wide wavelength range without changing a polarization extinction ratio of laser light and without changing a branching ratio due to fluctuation in a polarized wave. Moreover, when using an optical isolator as a polarizing means, output light of the optical isolator
25 becomes a constant polarized wave and an adverse effect due to light returning to a variable wavelength light source or an intensity varying means is removed so that laser light with more stable intensity can be obtained.

[Brief Description of the Drawings]

[FIG. 1]: FIG. 1 is a block diagram showing the first embodiment mode of a variable
30 wavelength light source apparatus according to the present invention.

English Translation of JP 10-313146

[FIG. 2]: FIG. 2 is a diagram showing a structural example of a variable wavelength light source of the variable wavelength light source apparatus according to the present invention.

[FIG. 3]: FIG. 3 is a block diagram showing the second embodiment mode of a variable wavelength light source apparatus according to the present invention.

[FIG. 4]: FIG. 4 is a block diagram showing the third embodiment mode of a variable wavelength light source apparatus according to the present invention.

[FIG. 5]: FIG. 5 is a block diagram showing the fourth embodiment mode of a variable wavelength light source apparatus according to the present invention.

[FIG. 6]: FIG. 6 is a block diagram showing the fifth embodiment mode of a variable wavelength light source apparatus according to the present invention.

[FIG. 7]: FIG. 7 is a block diagram showing the sixth embodiment mode of a variable wavelength light source apparatus according to the present invention.

[FIG. 8]: FIG. 8 is a block diagram showing the seventh embodiment mode of a variable wavelength light source apparatus according to the present invention.

[FIG. 9]: FIG. 9 is a diagram showing a structural example of a variable wavelength light source.

[FIG. 10]: FIG. 10 is a block diagram showing a structure of a conventional variable wavelength light source apparatus.

[Description of Reference Numerals]

1: variable wavelength light source, 2: polarizing means, 2a: light polarizer, 2b: optical isolator, 3: branching plate (branching means), 4: optical receiver (intensity detecting means), 5: control circuit (controlling means), 11: intensity varying means

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